STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA SCHOOL OF TECHNOLOGY

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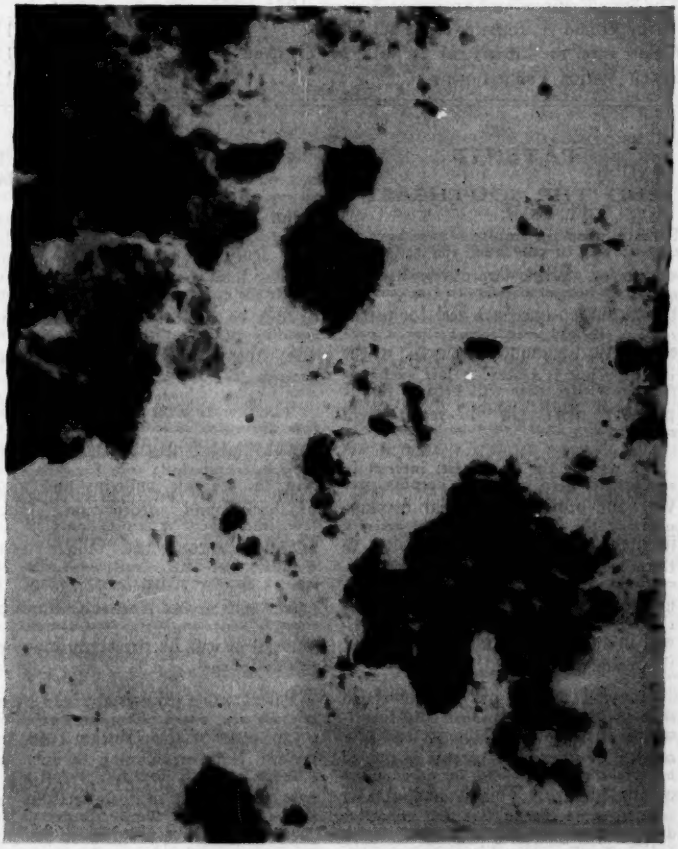

The Research Engineer

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PATENTS AND THE SOUTHEAST

Patents, properly employed, are keys to the gateway of continued industrial development. When improperly handled they may become barriers to free competition, but no one, in a zeal for patent reform, should ever forget that a patent's limited monopoly is no gift to the inventor but is instead a fair exchange for knowledge that will become public property after the 17-year patent period.

As regards the Southeast, interest in and attention to patents is keeping pace with the growing industrial development of the region. Industrial activity inevitably engenders inventive ideas in those men engaged in executing the operations involved; more and more, nowadays, these ideas are becoming crystallized into patents, many of which will in turn aid in the development of the region itself.

One industrialist has recently stated that the South was industrially handicapped because by far the greatest percentage of unexpired patents is owned by organizations based in other parts of the country. This is undoubtedly true to some extent, but this executive did not have the whole picture clearly in mind; the strength of the growing industrialization of the South is at least partially based on increased utilization of the resources peculiar to this region, so that new industries and new uses for old materials are continually being developed. At the same time, industries located elsewhere are awakening to the economies of operations contiguous to sources of supply and are building plants in the South, bringing with them their "know-how" and patents.

The literature on patents is most diffuse, including as it does the millions of patent grants; articles and books on their interpretation; and, for each given field, the journals, bulletins, and books of background information. Patent law, moreover, is most complex and seemingly inconsistent. There is no wonder, then, that much confusion exists as to the actual workings of the patent system, and it was to help dispel some of this confusion that the present series of articles on patents is appearing in this journal.

Patent work requires access to patent lawyers and patent libraries, both long conspicuous by their absence from this region. It is encouraging to note that Atlanta, at least, now has several attorneys specializing in these matters and that the Georgia Tech Library is engaged in an active program to assemble a comprehensive patent collection.

DRY BATTERY RESEARCH AT GEORGIA TECH

By G. H. KISSIN*

Dry batteries have long been in use, but, as for most industries, research is still needed on many technical phases, such as performance, service life, shelf life, etc. All of these, in turn, depend upon the raw materials involved, and it is on one of these—manganese dioxide—that Georgia Tech research is now centered. Problems of national defense, availability of suitable materials should natural sources be depleted, and the production of manganese dioxide of superior quality all combine to make this a research project of considerable significance and of particular interest to Georgia, which possesses deposits of manganese ore.

During the recent war, the U. S. Army Signal Corps experienced some difficulty in obtaining, for their wide variety of complex equipment, dry batteries of the Leclanche type which exhibited satisfactory service life under heavy current drains. The service life or activity of a dry cell is determined to a large extent by the chemical and physical properties of the manganese dioxide (MnO_2) employed as depolarizing agent** in the cell. Of the many sizable world deposits of naturally-occurring MnO_2, only one, located on the African Gold Coast, provides MnO_2 of satisfactory activity under heavy battery drain conditions. The strategic considerations involved in the Gold Coast deposits are obvious. Should this supply be cut off, it would be most difficult for the dry battery industry to maintain satisfactory quality in cells designed for heavy duty service.

In recent years, it has been found that, under proper conditions, synthetic MnO_2 can be produced which is far superior to the best available natural ores, especially under heavy battery drain conditions. At low drains, synthetic MnO_2 offers no material advantage over natural ores. The development of an efficient and economic process for the production of an active synthetic MnO_2 from domestic sources of manganese is therefore a matter of considerable importance for both military and normal commercial utilization.

There should be much local interest in this problem because of the wide distribution of manganese deposits in the Southeastern states. The deposits in the Cartersville area in North Georgia provide a notable example. The Burgess Battery Company at one time operated a small experimental plant in Cartersville for the electrolytic production of battery MnO_2. The reasons for the discontinuance of this plant have not been made public.

PURPOSE

In order to gain basic information on methods of improving dry battery performance, the U. S. Army Signal Corps, in June, 1946, contracted with the Georgia Tech Research Institute for that organization, through the Georgia Tech Engineering Experiment Station, to "conduct research investigations leading to fundamental information which may be used to improve primary or secondary batteries, or both, so that they will be more suitable as sources of electrical power. The investigation shall include:

"1. A fundamental study of manganese ores to determine the physical and chemical properties of the best battery ores,

"2. An investigation of processes for producing the best ores, and

"3. A fundamental study of the reactions in a cell with the view of increasing battery shelf life and capacity over the extended range of temperatures and conditions which might be met in storage and use."

It was subsequently decided that chief preliminary emphasis should be given to the second phase—the synthesis of active ores. However, such supplementary work on phases (1) and (3) were to be conducted

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**The mechanism of depolarization is not yet clear. A new theory, which has gained widespread acceptance, postulates that the most important reaction in cell discharge is: $Zn + 2MnO_2 = ZnO \cdot Mn_2O_3$. Manganese dioxide, according to this theory, acts as a receptor both for zinc dissolved at the anode and electrons which are removed from the cathode.

as would be required to evaluate properly the results of research on phase (2) and to keep the project in scientific balance.

The investigation logically may be divided into two fields, metallurgical and physico-chemical. The immediate aim is the study and development on a laboratory scale of a process for the production of MnO_2, with particular emphasis on the influence of the process variables upon the structure and battery properties of the MnO_2 produced. This involves electron microscope, X-ray and electron diffraction, and chemical studies of the synthetic products. Dry cells made up with the synthetic depolarizer are subjected to initial and delayed discharge tests, and the results of these tests will be correlated with the structural characteristics of the samples. This information should establish the desirable physico-chemical features of depolarizer structure, one of the most important functions of the project.

PROCESS REQUIREMENTS

A suitable process for the production of synthetic active MnO_2 should meet the following requirements:

1. The process should be applicable to a variety of types and grades of primary sources of manganese.

2. The variables involved in the formation of the active MnO_2 should be known and controllable to the extent that the process is commercially feasible.

3. The economics of the process should be such that the synthetic product can compete with natural ore on the basis of improved performance and selling price. The question of cost, however, may assume minor importance during a period of national emergency.

There are three major procedures which may be used to synthesize an active ore. Briefly, these are:

1. Electrolytic. A solution of manganous sulfate is electrolyzed, a deposit of manganese dioxide being formed on the anode and hydrogen gas being liberated at the cathode.

2. Chemical. Several precipitation methods have been proposed: oxidation of manganous sulfate with persulfate, dichromate, or permanganate; reduction of permanganate; extraction of lower oxide such as Mn_2O_3 or Mn_3O_4 with sulfuric acid, etc. None has been reported as satisfactory on an economic basis, although the extraction process using a lower oxide of manganese should bear investigation.

3. Beneficiation. Such methods induce direct conversion of inactive into active ores. Beneficiation may involve controlled heating, grinding, thermal shock, or any other process capable of inducing the required crystalline change.

Of these three, the electrolytic method seems to be the one offering the greatest possibilities at present. At least three major dry battery companies are known to be actively interested in this procedure. In its essentials, the electrolytic process involves a reduction of the raw and often impure ore, either chemically with sulphur dioxide or by heating to manganous oxide, treatment of the reduced phase with sulfuric acid to form manganous sulfate, neutralization to precipitate impurities as insoluble hydroxides, filtration, and final electrolysis of the substantially pure solution of manganous sulfate. The chemical and beneficiation processes have been tried at various times in the past but have not received the interest accorded the electrolytic procedure, probably because of the lack of control over uniformity. In work on this project, it seemed advisable to concentrate on the electrolytic process as offering the most promise, although the chemical and beneficiation procedures should not be ignored.

ELECTROLYTIC PROCESS

Little accurate information is available concerning the battery activity of MnO_2 produced in synthetic processes, and even less is known of the effect of process variables upon the activity of the product. Metallurgical considerations, at least, would favor an electrolytic process, since it would be no great problem to prepare a suitable, purified manganous sulfate solution from most manganese ores. Furthermore, the electrolytic procedure lends itself readily to a continuous

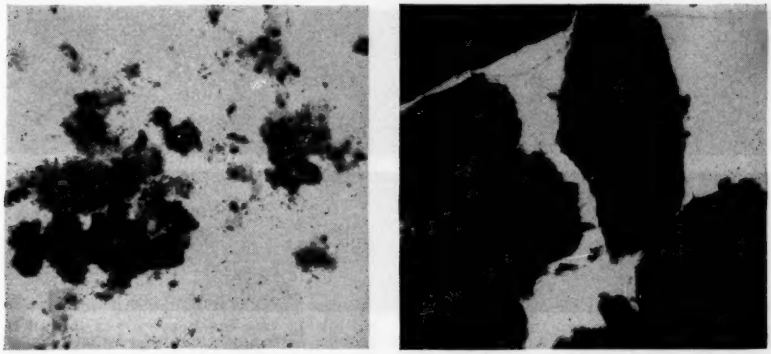

Figure 1. The feathery, diffuse structure shown in the left electron micrograph of a Georgia Tech synthetic manganese dioxide sample is associated with superior battery activity to that obtainable from samples which possess the coarse, crystalline structure shown at right.

industrial process employing spent acid electrolyte to leach ore to produce fresh purified electrolyte.

Because of the unsatisfactory state of the prior art, especially with respect to battery activity of MnO_2, it was decided to attempt an entirely fresh attack on the problem. After the development of procedures for the preparation of pure manganous sulfate solutions from available manganese sources, the following variables involved in the electrolytic process are being systematically investigated to determine their influence upon the structure and battery activity of the MnO_2 produced, and upon the efficiency of the process:

1. Concentration of $MnSO_4$ and H_2SO_4.
2. Addition agents and impurities.
3. Cell temperature.
4. Anode current density.
5. Anode and cathode material.
6. Cell voltage.
7. Electrode spacing.
8. Agitation.
9. After-treatment of product, such as leaching to remove acid, and grinding.

GEÓRGIA TECH METHOD

Research and development at Georgia Tech has progressed to a stage where the main features of the ultimate process have already been developed. MnO_2 is produced at a graphite anode by electrolysis of a solution of manganous sulfate and sulfuric acid. A small overflow of acid cell electrolyte is maintained continuously. This acid overflow solution, usually referred to as spent electrolyte, is employed to leach manganous oxide, MnO, which may be easily prepared by furnace reduction of crude MnO_2 ores. The leach is carried to neutrality, and all major metallic impurities are precipitated. The final purification is carried out by treatment of the neutral manganous sulfate solution with zinc dust to remove the last traces of those heavy metals below Mn in the electromotive series. The pure neutral manganous solution is fed continuously to the electrolysis cells. The spent electrolyte overflow and the purified solution feed to the cells are so adjusted that the manganese deposited on the anodes from the cell solution is replenished at such a rate that the cell electrolyte composition remains constant during extended periods of operation. Anodes are removed periodically from the cells for stripping of MnO_2, which is dried, ground, examined physically and chemically, and shipped to the Signal Corps' Squier Signal Laboratory at Fort Monmouth, New Jersey, for manufacture of test batteries.

Research has progressed simultaneously on the structural characterization of the MnO_2

Figure 2. The X-ray diffraction pattern of a Georgia Tech synthetic MnO_2 sample, shown at top, has diffuse lines and is characteristic of a gamma structure. According to present theory, confirmed by preliminary tests, this ore exhibits superior battery activity to the Java ore sample pictured below, whose X-ray diffraction pattern contains sharp lines, many of which are characteristic of battery-inactive pyrolusite.

produced. It is only in comparatively recent years that a reasonable theoretical treatment of the mechanism of dry cell discharge has been formulated. Space does not permit a complete presentation of the modern theory, which has been touched upon earlier in this article. However, certain conclusions concerning the structural requirements of active MnO_2 have been deduced from this theory.

The criteria now accepted for the appearance of a battery-active MnO_2 under the electron microscope are:

1. A low order of crystallinity. The particles should be small and their outline fuzzy or feathery. Well-defined crystal planes should not be in evidence.

2. A high order of particle dispersion. Clumping or clustering of particles is undesirable.

Electron micrographs of Georgia Tech synthetic MnO_2 samples which exhibit opposite extremes of the above properties are shown in Figure 1. The sample at left shows the feathery, diffuse structure which is considered desirable in battery MnO_2. The particles in the sample pictured at the right are coarse and definitely crystalline in character, and considerable clumping is evident. It would therefore be expected that this latter sample should be less active in dry cells than the first one. However, reliable service tests of batteries require over a year's time, and full confirmation of these predictions is not presently available.

Further structural characterization of battery manganese dioxide is obtained in X-ray diffraction experiments. A study of X-ray diffraction patterns reveals that manganese dioxide occurs in a number of forms, the most important of which are termed gamma, delta, and pyrolusite. It is now believed that the X-ray diffraction spectrum of a desirable battery manganese dioxide should show a predominance of lines characteristic of the gamma or delta phases, with little or no pyrolusite. The gamma and delta phases give diffuse lines in their X-ray diffraction patterns, indicating that they are poorly crystallized forms of manganese dioxide. Pyrolusite, which is not battery active, gives sharp lines characteristic of highly crystalline material. This lends support to the criteria established for the appearance of an active ore under the electron microscope.

Figure 2 illustrates X-ray diffraction patterns of two manganese dioxide samples. The Georgia Tech sample, shown at top, is predominantly gamma MnO_2, with diffuse lines and an undefined center. The Java ore sample, at bottom, shows a well-defined center, a sharp diffraction pattern, with lines

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PATENT SEARCHING

By JOHN C. LANE*

This is the third of a series of articles on patents, designed to remind the engineer and industrialist that aspects of this subject are of great significance to sound industrial development. In this article are considered those problems of patent and literature searching which must be considered by the inventor who desires to conduct and to protect his research with proper regard for economy and efficiency. Such a consideration is of particular significance in the light of Georgia Tech's present efforts to provide the Southeast with an adequate patent library.

"Search before you research" has been suggested[7] as a modern paraphrase of the old adage, "Look before you leap." No advice could be more valuable or, in some cases, more unheeded. Company records abound in chronicles of huge sums spent to develop processes or products which, when completed, were unpatentable or were later found to infringe upon existing patents. However, experience is the best teacher, trite as the saying may be, and an ever increasing number of companies are realizing that relatively small sums expended for adequate patent searches are valuable insurance against the far greater losses incurred in wasted research or lost lawsuits.

TYPES OF SEARCHES

The saving of money and time is not the only reason for preparing a patent search. Such searches may serve one or more of several different purposes, by which they may be classified accordingly into: (1) novelty searches, (2) validity searches, (3) infringement searches, (4) state-of-the-art searches, (5) patentee searches, (6) assignment searches, (7) identity searches, or (8) title searches. Generally speaking, each of these searches differs from the others, and several may be undertaken at some specific time in the overall progression from idea to commercial operation.

The *novelty search* seeks to determine whether the concept is patentable in view of previous patents and possible anticipation in the literature. The sooner such a search is made after an idea is born, the greater its value to the hopeful inventor. If the novelty search shows definitely that the invention is not patentable, the expense of fruitless experimental research can be avoided. Furthermore, the novelty search is likely to turn up information of great assistance in the future research and can act as a guide in preventing progress down a path already covered by patents. Not infrequently, an existing patent will suggest a patentable improvement, while other patents pertinent to the subject stand as red traffic lights to prevent a possible collision in the courts at the later date. Novelty searches are ordinarily restricted to a precise invention and are consequently less inclusive than the state-of-the-art search, which will be defined later. Another name for the novelty search is "preliminary examination," and such a search is often referred to by patent searchers as a "pre. ex."

The *validity search* is usually diametrically opposite to the novelty search in purpose. Such searches are often conducted in instances where a company would like to enter a field covered by an existing patent but fears that it would be sued for infringement if it did so. On the other hand, if a company already is operating in a field supposedly covered by a competitor's patent, it should certainly be sufficiently farsighted to anticipate a possible infringement suit and to institute a validity search in the hope that it can prove, in the event of court proceedings, that the existing patent is invalid. Briefly stated, "a validity search is instituted to determine whether or not the adversely owned patent can be sustained in court should an infringement suit be brought."[7]

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In keeping with their purpose, validity searches are most exhaustive, delving into all possible patent and literature sources in the hope of finding anticipatory references. They are sometimes undertaken, incidentally, by organizations about to enter a field in which they possess (or can purchase) patents, in order to obtain assurance (if possible) of the validity of the patents in question.

Infringement searches are made for one of two purposes: (1) to determine whether an unexpired patent exists which would be infringed by the manufacture of a certain product or the use of a certain process, or (2) to determine whether one existing patent infringes upon another.

Naturally, it is only good common sense for a company to make an infringement search before it installs a process in its plant or begins the manufacture of a specific product. Otherwise, it might spend large sums of money preparing for an operation that is prohibited by a patent in force or might actually operate until halted by a costly infringement suit. It sometimes happens that one duly issued patent infringes upon an earlier valid patent, and it is to the advantage of the company holding the prior patent to prove this. In such a case, both companies are likely to undertake infringement searches in the hope of locating material to support their contentions. Such searches generally can be limited to United States patents issued during the previous seventeen years, since only a patent still in force can be infringed, and a foreign patent cannot be infringed in this country (where it has no legal status).

In instances where a company's existing patent infringes upon an earlier patent adversely owned or is infringed by another company's more recent patent, the discovery of an earlier patent, United States or foreign, or any literature reference anticipatory of both existing patents in question, would invalidate both equally and prove a double-edged sword, although it would clear the field for free competition. Thus, only the infringing company would have anything to gain by extending the infringement search into a validity search; and its possible advantage would consist solely of clearing the field for its participation and the participation of all and sundry. However, where an infringement search is undertaken to determine whether the company can enter a given field without infringing upon an existing patent, the location of such an earlier reference would make it advisable to extend the search into a validity search in the hope of removing the restrictive patent by proving it invalid.

State-of-the-art searches are the broadest in scope of the several types of patent searches, in keeping with their purpose: the investigation of all relevant art before undertaking a research and development program. While none of the previous types of search can safely ignore the published literature, a state-of-the-art search would be sadly incomplete unless a correspondingly comprehensive literature search were also made. This fact is apparent from consideration of the four functions which one author has specified for state-of-the-art searches:[7]

(1) To indicate how unnecessary research expenditures may be avoided by pointing out lines of attack already covered by patents,

(2) To determine how far, and along what lines, research and development can proceed without infringing some unexpired patent, and to point out how the research program may be planned to avoid such legal difficulty,

(3) To suggest things to be done; i.e., by showing all that has been done in the past, to serve as a source of ideas for new research or development of patentable improvements on existing products or processes, and

(4) To indicate with some certainty the scope of patent protection which the company might reasonably hope to obtain in the light of the existing art, thereby giving a valuable indication of the economic advisability of entering the field.

The state-of-the-art search, sometimes called a "collection search" where absolute completeness is desired, is broad enough to give a fairly good indication of both the

commercial and the research activities of potential competitors and can be used roughly to evaluate their virility by comparing their respective patent situations. Another function which can prove extremely valuable is the discovery of expired patents which may be directly adaptable to the desired operation and the practicing of which has become public domain.

While most patent searches fall into one of the four main classifications previously described, the patent literature is also sometimes searched for information of a more narrowly specialized nature. For example, it might be informative to know the patent interests of a particular company or individual. In this case, a *patentee search* would be made to locate all the patents assigned to that company or person. Where patents have been assigned directly to the company at date of issue, this information can be obtained from the *Official Gazette*. However, where knowledge of a company's entire recorded interests is desired, an exhaustive *assignment search* must be made at the Patent Office itself in order to obtain a full record of assignments, licenses, or agreements made at dates subsequent to issue.

Other types of patent searches include the *identity search*, made to find, from identifying facts, one or more specific patents known to exist but of unknown number, or to determine whether or not a patent has been issued to a specific party in a specific field; and the *title search*, conducted in order to determine ownership of a given patent.

PATENT OFFICE SEARCHING

There is no doubt whatever that the best place to make a patent search, regardless of type, is the United States Patent Office in Washington. In its search room, all the United States patents ever granted are on file, classified into over 300 main classes and thousands of subclasses. "In making searches at the Patent Office, not only does the searcher have available the classified patents (U. S.), but he has access to the files of such patents containing the various Patent Office proceedings leading up to their grant, including the original application papers and amendments thereto and the official communications of the examiners who examined the application, in which are references to the prior patents and publications which the examiners found on their search and considered relevant to the invention claimed. By examining the files of U. S. patents which are of nearest subject matter to the investigation in question, it may be possible to obtain reference to prior patents or publications which are of particular interest and which would not be readily available elsewhere."[1]

Each such file thus constitutes a partial, ready-made patent search in regard to the patent to which it pertains and indicates the identity and classification of the related prior patents referred to therein. This often results in bringing to attention not only the prior patents of relevant subject matter, as mentioned, but also classes and subclasses which might not have been considered by the searcher but which may contain patents sufficiently related to merit investigation. "The number of classes and subclasses is so great and the classification of patents is in many instances so complex that relevant classes or subclasses may well be overlooked unless special precautions are taken to insure their proper consideration."[1]

In addition to offering by far the greatest advantage for the location of information on United States patents, the Patent Office has all or practically all of the printed specifications and publications emanating from the various patent offices of the entire world. The specialized scientific and technical libraries of the many Government departments and bureaus also can prove most helpful to the searcher fortunate enough to be able to make his search in Washington.

However, not every inventor is in a position to visit the Patent Office personally. Such a person would then do well to have his searching done by a reliable Washington patent attorney or professional patent researcher, since a skilled searcher with all of the Washington facilities available to him can not only make a more complete search, but can also make it in much less time. More rapid completion of the search often more than offsets the high unit cost of the professional's time and results in a less expensive search than the inventor could possibly make

himself. Even more important, since filing dates are so important, the quicker completion of a patent search by a professional can mean the difference between obtaining patent protection for an invention or being anticipated by a patent disclosed while the inventor is still making his search.

Many organizations find it advisable to maintain their own patent attorneys in Washington. A substantial number also have information services which specialize in preparing patent and literature searches. Such information service groups can make all types of patent searches and thereby service the company's research personnel. By bringing to attention, through regularly published bulletins, the current patents related to the company's field of interest and the developments announced in the literature, information services constitute a form of the continuous state-of-the-art search and stimulate inventive minds in the same way that such a search often does. Such services often collect continuous files of pertinent patents and literature on selected subjects,[6] so that the state-of-the-art is known at all times and the company activities can be directed by this knowledge.

Information service groups can be of considerable assistance to the patent attorney in the preparation of patent applications, although their help usually consists primarily of supplying him with searches and providing liaison between him and the inventor. The wording of claims for the broadest possible coverage is usually left completely to the patent attorney, whose legal training and specialized experience render him best qualified for this most exacting task; the wording of claims is an art in itself.[2]

CLASSIFICATION SYSTEM

The research tools available for patent searching are quite numerous, and it may be of interest here to identify them and to discuss their utilization in the preparation of the various types of patent searches. As mentioned, United States patents are classified by a system having over three hundred main classes and thousands of subclasses. If the searcher can satisfactorily determine the identity of all the classes and subclasses under which he could possibly expect to find pertinent patents, he can then purchase lists from the Patent Office giving the numbers of all patents classified in each class or subclass. Armed with this information, he can then obtain copies of the patents, study them, and determine whether they have any relation to his invention. Unless the invention is very broad, not all (and frequently very few or none) of the patents in a given classification will be found to be pertinent. The Patent Office classification system is very broad, as any system which is required to classify some two and one-half million miscellaneous ideas would have to be, and for complete coverage it is necessary that the greatest care be exercised in selecting the classes and subclasses to be investigated. If the searcher errs on the side of being too inclusive, he can only cause himself some unnecessary reading; but if he errs by failing to investigate a classification which later proves to contain a patent anticipatory of his invention, he can lose the fruits of all his subsequent research and developmental work in addition to having wasted time on a search which proved misleading.

The research tool which is generally utilized first when a patent search is undertaken is the *Manual of Classification of Patents*, an official publication of the United States Patent Office whose use makes possible the identification of the appropriate classes and subclasses. The main part of the Manual is the "Classes and Subclass Schedules" which lists each class and every subclass under each class. An index in the back of the Manual lists alphabetically all the kinds of "things" for which patents have been issued, including most of the words that appear in titles and subtitles of classes and a number of other words which do not so appear but which render the index more valuable. Since classes and subclasses are continually being added or revised in scope, the Manual is bound in a loose-leaf binder, and the Patent Office supplies new pages when classifications are changed. Additions to or revisions of the classification system are also recorded in the *Classification Bulletin* which is issued by

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THE WIND TUNNEL IN INDUSTRY

By ALAN POPE*

Engineers and the public alike usually think of the wind tunnel as an instrument applicable only to the aeronautical field. As this descriptive article attests, this conception is far from correct, and wind tunnels at Georgia Tech and elsewhere are busily engaged in rendering service to industries of many descriptions.

In recent years it has become evident that the wind tunnel, long an important tool for aeronautical research, has also a prominent role to play in nearly every industry: from cotton mills to auto design; from air conditioning to locomotives. Any industry which deals with processes involving air in motion can make profitable use of the controlled air flow conditions maintained in the tunnel.

The wind tunnel itself is not a familiar piece of apparatus, but the general public has an approximate and fairly correct idea of its shape and function: a tunnel of 1 to 30 feet in diameter in which the controlled flow of air from 0 to 150 miles per hour is possible.** Georgia Tech has two such tunnels: one 2½ feet and one 9 feet in diameter (shown in Figure 1). Primarily, wind tunnels are built for aeronautical research, but their peculiar characteristics of flow measurement have found application in the design of boats, trains, windmills, smokestacks, radio towers, automobiles, and bridges, and in the study of roof stress, air-conditioning duct systems, dust problems in populated areas, drying, ventilation, smoke abatement, etc.

AIR CURRENTS

So exceedingly broad is the scope that it is hard to pick a starting place in any discussion of the ramifications possible in tunnel testing. Perhaps the amazement on the faces of the United States soldiers who first reached one of the Japanese wind tunnels would do. Surely in time of war the tunnels of a beleaguered country might be expected to be running night and day on war projects. This particular tunnel, however, had no war project under way at all. To the amazement of the members of the American Scientific Evaluation team, it contained a model of a Japanese city that suffered from factory smoke nuisance, a model constructed in order to determine by tests what improvements could be made. Laudable as the benefits might be, the choice of time for the solution of this problem scarcely seems reasonable. The experiment, however, is noteworthy as an example of one type of wind tunnel test that many cities could use to advantage. Sometimes topographical changes entirely within the scope of modern

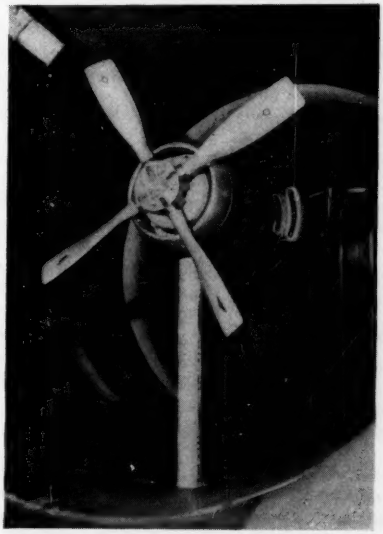

Figure 1. Engine nacelle in Georgia Tech nine-foot wind tunnel.

*Associate Professor of Aeronautical Engineering.

**Some tunnels are larger, while a few tunnels for special applications employ air at velocities as high as 600-3,000 miles per hour.

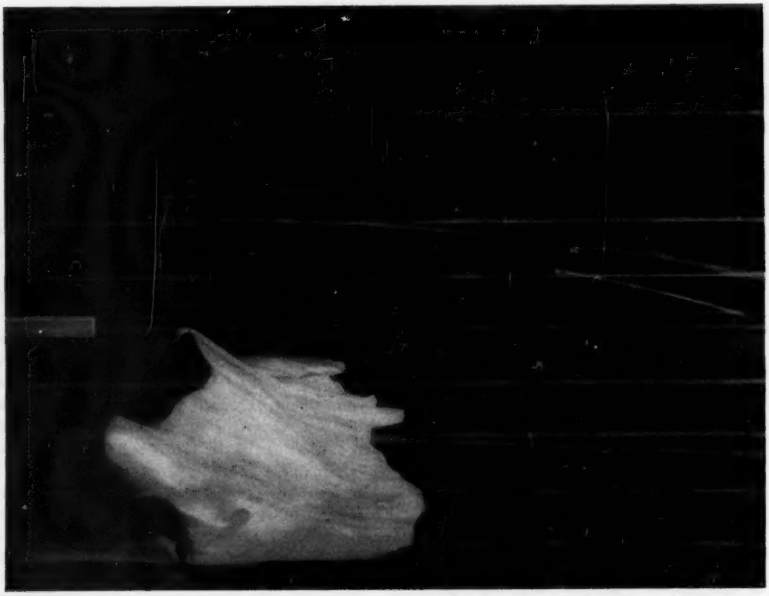

Figure 2. A model of the Rock of Gibraltar in a British wind tunnel. From the study made of this model, pilots learned the safe approach to the airport. (Courtesy of the Director of the National Physical Laboratory: British Crown Copyright Reserved.)

bulldozers can greatly alleviate a serious smoke nuisance.

The British were faced with a similar problem with their air field at Gibraltar, which rests in the lee of the "Rock." The air currents about the Rock are quite tricky, and several planes had been lost while making the last leg of the landing approach. As shown in Figure 2, a model of the Rock placed in the wind tunnel and studied under smoke and tuft flow enabled courses to be laid out that avoided the most serious places of turbulence, thereby ending the accident toll.

LOAD TESTING

Any building is subjected to air loads when the wind blows. These loads, particularly when the structure is high or the wind of near-hurricane velocity, may cause local failure of the roof covering or destruction of the entire structure. Here again the wind tunnel can help. A short program with the model of an existing building may show how minor alterations might relieve local pressure conditions, or it may demonstrate how catastrophic loads could arise when the wind exceeds a certain velocity. Many famous buildings have been tested, in model form, in a wind tunnel—the Trylon and the Perisphere of the New York World's Fair being well-known examples.

One structure that should have been model tested in the tunnel before it collapsed was the famed Tacoma Bridge. This structure, apparently designed in a satisfactory manner according to previous criteria, had an unusually narrow roadway for the length of the bridge and was located in a natural cut where high wind velocity was frequent. The jumping actions of the bridge before failure showed the need for wind tunnel

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THE STATE ENGINEERING EXPERIMENT STATION 1946-1947

By GERALD A. ROSSELOT* *and* PAUL WEBER**

This is the second annual report of the Georgia Tech Engineering Experiment Station to be described in this publication. In this article is an account of the Station's growth and progress during the past fiscal year. While only brief mention is made of individual research projects, their increasing number and budgets are making it possible for the Station to fulfill its aims and purposes to an ever-greater extent.

As has been the case in every year since its beginning, Engineering Experiment Station activities during the year 1946-1947 set another record, materially surpassing the previous record year, 1945-1946. Many phases of activity were expanded, and several new functions were added to those already in existence. Extensive research programs were carried out on problems related to the national security and in the fields of industrial research, fundamental studies, and the development of the State's natural resources.

The various departments of Georgia Tech were most active during the past year in their participation in the research program. Typical departmental projects included an FM propagation study of the Atlanta area (Electrical Engineering), research on water and sewage analysis (Civil Engineering), and the study of two-coat paint systems on Southern yellow pine (Chemical Engineering). In addition, members of these departments and the departments of Physics, Aeronautical Engineering, Chemistry, Mechanical Engineering, Public Health Engineering, and Ceramic Engineering directed or assisted with many of the Station's projects, in keeping with the Station's policy of encouraging faculty members of the School to engage in scientific research along with their teaching duties.

The Station's budget for 1946-1947 totaled $325,000, which was considerably larger than the one administered during the preceding year. Approximately 81 per cent of the funds came from outside sources, including cooperating agencies, industry, and the federal government, while 19 per cent came from the School, including endowments and funds from the Board of Regents. The above-mentioned increase in the budget over that of the preceding year was due entirely to increased support from outside sources. Of some importance is the fact that work already in progress on recently initiated projects in addition to that planned for continuing projects indicates that a further increase in outside support will be experienced during the year 1947-1948.

Work was carried out on thirty major research projects and eighteen minor or special projects during 1946-1947, requiring the full-time services of 66 persons and the part-time assistance of more than 100 others. New additions to the full-time staff included two Research Associate Professors, two Research Assistant Professors, two Research Engineers, 15 Research Assistants, 11 Technical Assistants, an accountant, and several additional secretarial and clerical employees. An increased number of graduate and student assistants were utilized for work on Station projects. Many of the graduate students are employed as research assistants on outside-supported projects and, consequently, are doing their thesis work on what amounts to practically a fellowship basis. The Station's part in the purely academic side of the School's activities is further illustrated by the participation of the permanent research staff members in the Graduate Studies program, through graduate course instruction and service as graduate thesis advisors.

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FACILITIES

During the year, extensive additions were made to the Station's space and equipment facilities. Foremost among these was the new Station Annex, nearing completion at a cost in excess of $150,000. This annex, although it increased by 25 per cent the amount of available floor space, is far smaller than that originally planned and then and now vitally needed. A new A.C. Network Calculator, with its accessory equipment, is being installed in the first floor of the Annex at a cost of approximately $120,000. The second floor of the Annex is divided into small research laboratories, some of which will house facilities for investigations of the fundamental properties of matter at very low temperatures. Other special research projects will also be conducted in this new building.

In the pilot plant area of the main Research Building, two new balconies were built during the year, and the space beneath one of them converted into four small research laboratories. Pilot plant equipment was installed on the balconies themselves. In addition, three refrigerated work rooms, totaling 350 square feet in area and capable of being maintained at 0° F., were installed; these rooms were equipped as laboratories for studies of food preservation methods. Additional equipment (of a pilot plant nature) for these food studies was installed on one of the new balconies.

At the rear of the Research Building, a new 20 x 54 foot aluminum building and a temporary 16 x 16 foot building were erected and equipped for use in electronics research projects and meteorological studies. A 12 x 18 foot penthouse was built on top of the Physics Building to house some special radio transmitting equipment.

Two five-room houses adjacent to the Research Building were converted into temporary laboratories and offices. A well-equipped electro-chemical laboratory and a group of offices and drafting rooms were set up in one of the houses; all the work carried out in this house is on projects for the armed forces. The second of these two houses was converted into the Station's Photographic and Reproduction Laboratory. The reproduction rooms contain photostat, ozalid, and various other copying machines. Three dark rooms were built, all of which can be maintained at a constant temperature of 68° F.

Several new special buildings have been built and others are in the process of being completed in a segregated area in the northwest part of the Campus, to house the facilities of two research projects. The cost of these new buildings, exclusive of internal facilities, will exceed $50,000.

In order to provide 3000 square feet of additional space for use on several new research projects, another new temporary building (wood construction) was recently completed. Extensive new facilities of a special nature were built and installed in several of the School's engineering departmental buildings.

New equipment received or constructed during the year included numerous instruments, among which were a spectrophotometer, photofluorometer, microscopes, supersonics units, and low temperature calorimeters; equipment for producing liquid hydrogen; various refrigeration equipment, including a liquid air plant; and considerable radar and electronics equipment. Much additional specialized equipment was furnished by the armed forces, for use on special projects. In addition, new machine tools valued in excess of $25,000 were installed in the research machine shop.

SERVICE DIVISIONS

The Station was particularly active in expanding the functions and utility of its service divisions. The Engineering Design Division was enlarged and is now responsible for the majority of all the mechanical design and drafting connected with research projects. In addition, this division serves as a control point for work performed by the machine and fabrication shops. The services of this division, in cooperation with the Technical Information Division, are available for the preparation of invention records and preliminary work for the drafting of patent applications.

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REPORT FROM THE LIBRARY

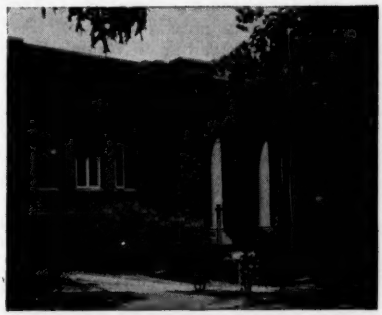
By DOROTHY M. CROSLAND*

Those of you who used this library almost daily while you were in college must be wondering where we have shelved even one book since you departed from your Alma Mater. Even though it involved cutting down on student reading space, low book stacks have been placed in the centers of the reading rooms, and shelves have been built to the ceiling. Seventeen rooms in Knowles Dormitory have also been used. This summer, the basement of Knowles has been assigned to the library, and all the books and journals stored in the seventeen rooms have been transferred there. It is not an ideal arrangement—Knowles is a virtual fire trap—but we do have a little more shelf space, located in adjoining rooms. It seems as though we cannot progress much further until we get a new library. The latter, unfortunately, seems far in the future, but it remains a dire necessity.

Our total of books and bound periodicals is now slightly over 85,000, and we currently receive approximately 1,600 journals. Our library—your library—is serving a student body of 5,000, a faculty of 450, the faculty families, school employees, and many engineers and research workers in this region. We have many requests for inter-library loans from places as far away as Ontario, Canada, California, and Texas, as well as from neighboring states. Our collection does and will support the graduate work and research of our institution.

This year, we have made many notable additions. My journey to Europe in search of books and periodicals was fruitful, and I shall list at the end of this article some of the volumes that are now on our shelves. There are still others to come from England and Switzerland.

We are beginning to get quotations on scientific and technical materials, and we hope it will not be so difficult to make acquisitions this year. Some book dealers have opened offices in the American Zone in Germany. It may be some months, however, before books and periodicals are actually received from that country.



Along with the foreign material acquired, we have received copies of all the United States patents issued from May, 1946, to date. These are continuously bound and placed on our shelves. Also, we have been made a depository for copies of patents vested with the Alien Property Custodian; these have come and are also on our shelves. We have ordered the Abridged Patents of Great Britain from 1903 to date, the Abridgments from 1865-1902 having been received on exchange. Numerous reference books on patents and trade marks have been ordered, and we are delighted to be able to make patent information available to the research workers.

Another service recently started that should prove most beneficial is a map collection. We have been made a depository for the Army Map Service, and fifteen boxes of maps have arrived from Washington. This collection will be supplemented with other maps useful in an engineering institution. All these services will be made more readily available by an assistant who will be in charge of patents and maps.

The following journals have been added and are now part of our collection: *Les Ailes* (1921-1946); *Academie Royale des Sciences, Brussels, Bulletin* (1832-1942); *Akademie der Wissenschaften, Berlin—Phys-*

*Librarian, Georgia School of Technology.

ikalische—Mathematische Klasse (1932-1942); *Akademiia Nauk, Leningrad (Academie des Sciences) Bulletin* (1907-1927); *Alta Frequenza* (1936-1944); *Annalen der Physik (Poggendorff) Series II* (1824-1870, with some missing volumes); *Annales Scientifiques de l'Ecole Normale Superieure* (1864-1947); *Annali di Matematica,* Series IV (1924-1944); *Archiv fur Elektrotechnik* (1913-1924); *Bulletin des Sciences Mathematiques* (1870-1937); *Calcutta Mathematical Society Bulletin* (1909-1945); *Chaleur et Industrie* (1920-1945); *Christian Huyghens International Mathematicsh Tijdschrift* (1921-1940); *Deutsche Physikalische Gesellschaft, Verhandlungen* (1920-1939); *Dyer, Calico Printer, Bleacher and Finisher* (1893-1934, with missing volumes); *Edinburgh Mathematical Society, Proceedings* (1927-1945); *Elettrotecnia* (1914-1945); *Gazzetta Chimica Italiana* (1871-1936, with missing volumes); *Helvetica Physica Acta* (1937-1946); *Hochfrequenztechnik und Elektroakustik* (1912-1942); *Isis* (1913-1940); *Ingeniorsvetenskapsakademien, Meddelands* (1920-1943); *Jahrbuch der Elektrotechnik* (1912-1925, 1927); *Journal de Mathematiques Pures et Appliquees* (1836-1946); *Leyden Rijks-Universiteit, Communications of the Physical Laboratory* (1885-1942); *Mathematica, Afdeeling A en B* (1932-1944); *Melliand Textilberichte* (1925-1936); *Mineralogische und Petrographische Mitteilungen* (1932-1942); *Le Moniteur Scientifique* (1864-1880); *Monographien uber Angewandte Elektrochemie* (1902-1910); *Osiris* (1936-1939); *Revue Generale des Chemins de Fer* (1878-1944); *Revue Generale des Sciences Pures et Appliques* (1890-1921); *Revue Semestrielle des Publications Mathematiques* (1893-1935); *Societe Hollandaise des Sciences Archives* (1866-1933); *Societe Industrielle de Mulhouse, Bulletin* (1910-1938); *Stahl und Eisen* (1881-1922); *Svensk Kemisk Tidskrift* (1889-1945); *Technical Association of the Pulp and Paper Industry, Papers* (1920-1939); *Teknisk Tidskrift* (1870-1945); *Verein Deutscher Ingenieure, Zeitschrift* (1888-1899, 1916, 1918-1927); *Verfkroniek* (1939-1945); *Vliegveld, Amsterdam* (1915-1931); *Zentralblatt fur Mechanik* (1933-1942).

We shall continue our program of completing files of journals that will be needed for research or graduate study.

BATTERY RESEARCH

Continued from Page 6

characteristic of pyrolusite, and has proved unsuitable as an active battery ore.

Preliminary results on initial service tests of dry batteries made up with Georgia Tech electrolytic manganese dioxide, prepared during the early phases of this project, have been reported recently by the Battery Branch of the Squier Signal Laboratory. These are compared in Table I with test results on other battery manganese ores. Incidentally, the Georgia Tech sample reported in this table contained a fair amount of impurities and inert materials which are not present in more recent products.

Results obtained on batteries prepared from Georgia Tech ore and stored for three months show that service life is relatively unaffected by storage. According to the Signal Corps, these are the first batteries prepared with synthetic ore to exhibit such a degree of stability.

A systematic investigation of process variables is now in progress, with design data for a pilot plant as the ultimate goal.

TABLE I

COMPARISON OF BATTERY MANGANESE ORES

Ore	Average Hours Service (BA-2 Test)
Georgia Tech (Electrolytic)	115
African Gold Coast (Natural)	95
Caucasian (Natural)	75
Java (Natural)	63
Ergogene (Foreign Synthetic)	120
Company A (Domestic Synthetic)	98
Company B (Domestic Synthetic)	95

RECENT STATION PUBLICATIONS

BULLETIN

Vidosic, Joseph P., *Streamline Graphics*. Georgia School of Technology, State Engineering Experiment Station Bulletin No. 11, 1947. 20 pages. 75 cents.

Streamline graphics are today of considerable importance in the generation of satisfactory surface contours for the airplane, the automobile, the train streamliner, and the fast ocean ship. High speeds require regular, undisturbed curves, capable of mathematical definition, exact graphical construction, and accurate analysis.

This bulletin, after an introduction, is divided into the following sections: history, aircraft practices, reference system, conic construction, conic mathematics, curve matching, shell development, surface fairing, and conclusion. Twenty-one descriptive figures, many of which give the graphical details of constructions, are included.

REPRINT

Wilkins, Leonard and Weber, Paul, *Physical Studies of Paint Primers in Two-Coat Paint Systems Applied to Southern Yellow Pine*. Georgia School of Technology, State Engineering Experiment Station Reprint No. 21, 1947. 34 pages. 25 cents.

Realizing that two-coat systems were being increasingly used in the painting of new houses during the period from 1930 to 1940, the Southern Paint and Varnish Production Club and the Georgia Tech Engineering Experiment Station decided in 1940 to jointly sponsor an investigation into the effect of the physical properties of paint films, such as adhesion, elasticity, penetration into various surfaces, and relative hardness. The various pigments, extenders, vehicles, and driers which make up paints were also studied, and an experimental program was then outlined to test the effect of various combinations of primer coats with a standard topcoat, comparing all these with recognized two-coat and three-coat systems as standards.

This reprint of a paper published in the *Official Digest* of the Federation of Paint and Varnish Production Clubs lists in detail the several hundred different primers which were used in the study, in addition to the various pigments, vehicles, extenders, and driers which were employed. Actual exposure of test panels covered by the various paint systems is being conducted on a "paint farm" located ten miles north of Atlanta. A discussion of the results of the first six years of the tests is included in the paper, which concludes that, if proper primer-topcoat combinations are employed, two-coat paint systems applied to Southern yellow pine are practically equivalent to the best three-coat systems. Specifications for such systems are given.

CIRCULARS

Weil, B. H., *Information Service and the Petroleum Industry*. Georgia School of Technology, State Engineering Experiment Station Circular No. 10, 1947. 3 pages. Gratis.

Scientific and technologic developments of the past few decades have presented the petroleum industry with a wealth of published information for use in its highly technical, extremely diverse operations. This reprint of an article from the *Petroleum Refiner* describes the reasons for and the functioning of the information service groups which many petroleum companies have provided to interpret these data, as needed, and to condense, in a usable manner, the flow of current information.

While the petroleum industry is used as the example throughout the article, much of the discussion is applicable to any technical industry. Information service groups are often beyond the financial means of small companies; moreover, where there are many companies in a given field, much needless duplication could be avoided by some organized form of inter-company cooperation. In any case, the increasing flow of published information indicates an ever-greater need for technical information services.

***How Georgia Tech Serves Georgia Industry Through Research and Education*. Georgia School of Technology, State Engineering Experiment Station Circular No. 11, 1947. 8 pages. Gratis.**

This brochure, prepared by the Joint Committees on Research and Education of the Associated Industries of Georgia and the Georgia School of Technology, briefly describes the research and development facilities of the School, including contractual relations, scope of service, physical facilities

and equipment, typical research projects, testing and analysis, industrial and economic surveys, the technical information service, the Georgia Tech library, and the School's policy concerning publicity. Under the heading "Education" are grouped a series of brief sections on the School's undergraduate division, graduate division, extension division, and placement service.

Weil, B. H., *Plastic Makers Look to Petroleum Chemicals for Raw Materials*. Georgia School of Technology, State Engineering Experiment Station Circular No. 13, 1947. 7 pages. Gratis.

According to this review of the petroleum chemicals field as it regards plastic raw materials, the production of coal-tar chemicals is not likely to increase in the future, so that the plastics industry must give increasing attention to petroleum intermediates. This is still further true because emphasis in plastics production has shifted from the cyclic ("coal-tar") resins to acyclic resins, most of which are capable of being produced from petroleum.

The plastics industry is undergoing more than a two-fold expansion over its 1945 rate and appears to offer at least a stable market for petroleum chemicals. This article, reprinted from *Petroleum Processing*, discusses plastic trends and statistics and the economic factors which petroleum companies interested in this field must consider.

Weber, Paul, et al, *Round-Table Discussion on Painting of Southern Yellow Pine*. Georgia School of Technology, State Engineering Experiment Station Circular No. 14, 1947. 19 pages. Gratis.

This reprint of proceedings which appeared in the *Official Digest* of the Federation of Paint and Varnish Production Clubs constitutes a round-table discussion of many of the factors which affect performances of various painting systems on pine woods. Subjects discussed include properties of the various pine woods as related to painting characteristics, the need for immediate painting following use, pretreatment prior to painting, the extent to which pigmentation can be varied in controlled penetration titanium-white lead primers, the optimum pigment volume for controlled penetration primers, the alternate use of zinc sulfide and titanium dioxide in high-grade primers, the relative values of various primers and special primers as compared with self-priming systems, and the extent to which special priming paints (such as controlled penetration primers, aluminum primers, etc.) tend to even up the discrepancy in painting characteristics between Southern pine and such woods as red cedar.

Honnell, M. A. and Weil, B. H. (Editors), *Proceedings of the Broadcast Engineers Conference*. Georgia School of Technology, State Engineering Experiment Station Circular No. 15, 1947. 196 pages. Four Dollars.

These proceedings of the Broadcast Engineers Conference, held in Atlanta in April and jointly sponsored by the Georgia School of Technology, the Atlanta Section of the Institute of Radio Engineers, and the Georgia Association of Broadcasters, include 19 of the 25 papers presented at the conference and abstracts of the remaining six. Six papers deal with audio-frequency systems, three with propagation, two with studio design, three with antenna systems, six with FM transmitters and measurements, one with receiver design, one with television equipment, and three with general subjects (safety precautions for radio stations, status of FM broadcasting, and high frequency tubes).

All papers received were included in their entirety, along with graphs, drawings, and photographs. These proceedings are intended to provide a permanent record of many of the latest developments in the field of broadcast engineering.

EXPERIMENT STATION

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The activities of the Technical Information Division were expanded during its first full year of operation. In addition to preparing literature searches, this division edited THE RESEARCH ENGINEER and other publications and progress reports (in cooperation with the Station's editorial committee), directed the preparation of records of invention and patent applications, and handled the preparation of exhibits and other presentations of the School's research activities.

Several comprehensive literature searches were prepared for projects or directly for

outside industries. Coupled with Georgia Tech's excellent library facilities in the fields of science and engineering, this division is in a position to provide a service to industry which is not available elsewhere in the South. Its service functions were described in an article in the September, 1946, issue of THE RESEARCH ENGINEER.

The Industrial Economics Division continued its studies of the various economic problems affecting the industry of Georgia as a whole, the preparation of reports dealing with specific industrial problems, and the preparation for publication of economic studies of the pulp and paper industry and of the peanut processing industry.

As was mentioned earlier in this article, the Photographic and Reproduction Laboratory was activated during the year. This division provides photographic and reproduction services to all departments, organizations, and individuals at Georgia Tech who require such work in connection with their research and educational activities.

PUBLICATIONS

Progress reports on a number of the Station's research projects and on other activities of its staff were published in the form of technical bulletins and articles. Some 18 separate publications were released. In addition, 14 articles describing Station activities appeared in THE RESEARCH ENGINEER. These publications do not represent all of the Station's progress reports, of course, since many projects are of such a nature that publication of results cannot be made until a later date. Patent applications have been filed which are based on the work of several of the projects.

RESEARCH PROJECTS

Many of the research projects conducted by the Station are sponsored by outside organizations, such as private industries, industrial groups and societies, and governmental agencies, including the armed forces. The contracts for most of this research work are handled through the Georgia Tech Research Institute, which is a nonprofit organization, separately incorporated under the laws of the state of Georgia and closely integrated with the Georgia School of Technology.

The Institute serves to implement and coordinate the utilization of Georgia Tech research facilities by those industries, associations, governmental agencies, or individuals who may require these services in the search for new or better products, in the development of technical processes, or in the prosecution of fundamental research. The details of the organization were given in an article in the May, 1946, issue of THE RESEARCH ENGINEER.

Since the Station and the Georgia Tech Research Institute in many cases agree with outside sponsors of research to withhold publication of information of a confidential nature until such publication is mutually agreed upon, it is not possible here to list all of the Station's projects; moreover, space does not permit the description of the details of any of the projects. Most of the work which can be described has been or will be reported in THE RESEARCH ENGINEER or in formal bulletins.

Work in aeronautical engineering research dealing with the lifting airscrew and its possibilities as applied to helicopter flight was continued during the year. Improvements which were made in the state of the theory of hovering flight and vertical ascent were verified by checks with available experimental data.

A study of primers in two-coat exterior paint systems on southern yellow pine was practically completed. The major results, which were published, indicate that properly formulated two-coat systems are practically as durable as the older three-coat systems.

Vegetable oil studies were continued, with emphasis on methods of extraction of oil and protein from certain seeds, using aqueous media to assist in the recovery of the oil and protein.

A project dealing with frequency modulation propagation studies was essentially completed. Some of the other of the Station's electronics projects involve the correlation of radar measurements with meteorological data and studies in frequency control

in certain radio communications equipment.

Work was completed on the construction and testing of a new, high-speed peanut planter, capable of depositing evenly-spaced seeds 2-2½ inches apart at planting speeds up to nine miles per hour.

Extensive studies were conducted on the processing of ramie into fibers suitable for textile purposes, and preliminary results of this work will soon be published. Also of textile interest is a program of fundamental research initiated during the year on cellulose and forest products.

Additional work was performed on a large-scale experimental study of food preservation methods, particularly by freezing. Several publications have resulted from this work, and indications are that the data being obtained will be of considerable value to the frozen foods industry.

Of particular interest to Georgia, which possesses manganese ore deposits, is a project designed to determine how domestic ores can be processed for production of a synthetic manganese dioxide which is satisfactory for use as a depolarizer in dry batteries; preliminary phases of this study are reported elsewhere in this issue. Another project of particular interest to Georgia is a study of spectographic methods of determining iron and titanium in kaolins.

An extensive research program is being conducted in order to work out simple and rapid procedures for water and sewage analysis; such procedures would enable a better check to be kept on municipal water and sewage plant operations.

As mentioned, many other projects are in progress, and several new ones are under consideration. Every effort is being made to conduct these projects in an efficient manner, so that maximum service may be rendered to sponsors and to the development of fundamental knowledge.

The Engineering Experiment Station serves to coordinate and advance the research activities of the Georgia School of Technology and to aid in the development of industrial and agricultural activities of the State through its investigations and technological studies. During the past year, the Station has expanded its activities in all of these functions, and it is hoped that, in the future, it will have the opportunity of further increasing its services to the State and the nation.

PATENT SEARCHING

Continued from Page 10

the Patent Office and which lists all changes made in classes and subclasses during the period of time which the particular issue of the Bulletin covers. The individual changes are recorded in the Bulletin in chronological order, but a table of contents listing class number, class name, and the number of the page on which the change is reported serves as an index.

Once the searcher knows in what classes and subclasses the pertinent patents will be found, he may either buy from the Patent Office the lists of the patent numbers filed under the desired classifications, as previously mentioned, or he may attempt to locate the same information for himself through use of the *Index of Patents* and the *Official Gazette*. It is usually advisable to write to the Commissioner of Patents and to inquire how many patents are included in each desired subclass and what the Patent Office would charge for a list of the patent numbers therein. Generally, the purchase of such a list is the simplest and (if time is considered) the most economical method of obtaining this information.

However, if the inventor has more time than means, he may locate the patent numbers under a given subclass by reference to the *Index of Patents* and the *Official Gazette*, as mentioned. The Index, known as *The Report of the Commissioner of Patents* prior to 1920, is issued annually and lists all of the patents granted during the preceding year

(1) by patentee and (2) by subject (patent title), arranged in alphabetical order. While the Index is most useful in making an assignment search, because of its patentee listings, it requires careful study under all possible index titles if a broader type of search is being made. When the Index is used for the latter purpose, it is best to go through the most recent issue, locating possibly pertinent patent numbers, and then to consult the *Official Gazette* or printed copies of the actual patents before going on to the next earliest year, since an arduous search through the Index may be rendered unnecessary by the location of an anticipating patent in a recent issue. During the years 1916-20, the Index included a list of patents by subclasses in each annual volume, a feature which renders the location of the desired patent numbers relatively simple for those years.

For patents issued after July, 1933, location of the patent numbers listed under a given subclass may be accomplished fairly simply by employing the *Official Gazette*. The Gazette has been published weekly since 1872, but only since August, 1933, has it contained a list of patents by subclasses in addition to its traditional information on the patents granted during the week, such as patentee, title, leading claim or claims, and often drawings.

Once the numbers of the patents in each possibly pertinent subclass are obtained, either from the Patent Office or through use of the Index and the Gazette, it is necessary to determine their pertinence individually. Where they are available (Washington and a number of public and scientific libraries), the Specifications and Drawings issued by the Patent Office are the most reliable tool for this step. These consist of "soft copies," complete except for the grants, of all patents issued by the Patent Office, usually bound together in volumes and arranged in numerical order.

Some libraries contain incomplete sets of patent copies, and a large number do not have them at all. However, the *Official Gazette*, which publishes one or more claims and often includes a drawing, may give sufficient information to indicate whether a patent can be safely disregarded. If the pertinence of a given patent cannot be adequately determined from the *Official Gazette*, a copy of it may be obtained for twenty-five cents from the Patent Office, or a photostatic copy may be obtained from the same source at a nominal fee.

Once again it should be emphasized that the best place to conduct a patent search is Washington, D. C. Since access may be had directly to the classified files, it is only necessary to determine the classes and subclasses to be investigated and then to peruse the copies of the patents contained in those files, by-passing the *Index of Patents* and the *Official Gazette*. The Patent Office information filed along with the patents also constitutes a gold mine of data on related prior patents, as previously explained.

Some mention should be made of the fact that once an inventor has limited his field of interest to certain subclasses, he can arrange to receive, as issued, copies of all future patents so classified by opening an account with the Patent Office. All that he needs to do is to notify that office that he wishes to receive regularly all patents falling into certain desired classes and to deposit a sum of money, against which the Patent Office will draw twenty-five cents a copy as it sends him patents in the future. Occasionally the inventor will have to replenish the money in his account in order to continue to receive the patents, but he will receive a steady flow of information without further mental exertion.

FOREIGN PATENTS

Unless it is an infringement search, a patent search cannot safely confine itself to a consideration of United States patents only, although novelty searches (pre. ex.'s) of minimum requirements often cover no more territory. Validity searches and state-of-the-art searches, however, must exhaustively cover also the foreign patents and the related literature. Even in 1922, over 125 countries gave patent protection. However, at that time only 13 issued printed copies of complete specifications, and less than 33 issued official publications.[6]

Smith,[6] in 1924, compiled a list[6] of the patent reference sources available at that time.

In it, he named all the countries which then granted patent protection, listed the titles of the official publications of their patent offices, and made reference to other existing publications dealing with patents, such as special compilations, bibliographies, periodicals, etc. He also supplied a list of leading libraries having facilities for patent searching and indicated the official publications that they possessed. While the passage of time has made Smith's paper incomplete, it is still of value as a guide to the less-well-known official publications and the older special compilations; it stands, even now, as a model for the type of information needed today to assist the individual who may occasionally have to make a patent search but who does not devote the major proportion of his time to such work and is consequently not exhaustively familiar with the available sources. A most worthy project for some altruistic patent-search specialist would be the revision of Smith's paper; a recent paper[3] on certain of these aspects has been prepared by Egloff and Davis.

Reference to the official publications of those patent offices which publish them should be made in all validity and state-of-the-art searches. It is possible to order copies of patents from foreign patent offices which publish them, but the time element involved usually makes it desirable to consult the files of foreign patents maintained at the United States Patent Office or to order photostatic reproductions of them from that office. The procedure of determining what foreign patents should be ordered depends upon the facilities offered by the official publications of the country in question. However, the more important countries, notably Great Britain and Germany, have patent classification systems sufficiently similar to our own to make the task one of selection of pertinent classes and subclasses as described for searching of the United States patents.

Certain abstract journals are fruitful sources of reference, both to patents and the literature. For the chemist and chemical engineer, there are *Chemical Abstracts, Chemisches Zentralblatt, British Chemical and Physiological Abstracts, Chemiker Zeitung, Biological Abstracts*, etc. Others, such as *Industrial Arts Index* and *Engineering Index*, deal exclusively with the literature, but are of great value in the literature-searching phase of validity and state-of-the-art searches.

Trade journals sometimes make a practice of printing abstracts of patents pertaining to their special fields. A notable example of this is the *Petroleum Refiner*, which has long maintained a department entitled "Digest of Recently Issued United States Patents Pertaining to Petroleum Refining." This particular digest department not only prints abstracts of patents pertaining to refining, but also classifies these abstracts according to the various phases of the broad subject, such as alkylation, cracking and reforming, hydrogenation, isomerization, polymerization, etc.

Books of a review nature often, in themselves, constitute a fairly comprehensive state-of-the-art search for the years prior to their publication. While it is not safe to conclude that the field is clear if such a book does not indicate anticipation, it is certain that if the book does contain a reference to anticipatory work, a time-consuming and costly search may be avoided by checking it first. In the field of petroleum, for example, the two-volume work of Ellis[4] on "The Chemistry of Petroleum Derivatives" is a good example of such a book.

While this article has been primarily confined to a description of the main types of patent searches, the sources of information available, and the methods of searching, much could be said concerning the special uses to which patent searching can be put. Just as an example, let us assume a hypothetical case in which a large research laboratory was unable to analyze a competitor's product because its complex organic chemical constituents broke down under the necessary analytical conditions. The most painstaking analysis could only give an empirical formula based on the percentages of component elements and the detection of certain reactive radical groups. However, an assignment search of the competitor's patents turned up a patent which claimed the use of a certain organic chemical for the purpose for which the mysterious product was being marketed. All that remained was to obtain the pure chemical and to compare it with the mar-

keted product. Moreover, the patent re- vealed the raw materials used and the details of synthesis. This precise incident may never have happened, but it is a safe wager that very similar ones have and that the increasing appreciation of the utility of searches will make such occurrences more common as time goes on.

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WIND TUNNEL IN INDUSTRY

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tests, and such tests were actually under way when the final failure occurred. Later tests reproduced the motion that ended with the collapse of the multi-million-dollar structure. Wind tunnel studies of bridges, radio masts, smokestacks, and water towers can pay big dividends. It is no exaggeration to say that any structure lying demolished by a windstorm could have been built in a redesigned manner, or altered, and thus could have remained undamaged had wind tunnel tests been made and heeded.

STREAMLINING

Another type of test, not related to the subject of direct damage from structural failure, but certainly important in another way, was employed in the design of the Canadian National Railways' Model 6400 locomotive. This eight-driver locomotive showed up well in the performance of its expected duties, but smoke from the stack poured directly into the engineer's eyes. A wind tunnel model was constructed and put into the John's Street tunnel of the Canadian National Research Council in Ottawa, where the reason for the trouble rapidly became evident: certain of the locomotive's accessories were so placed that a smooth air flow over the cab was impossible. As pictured in Figure 3, relocation of several of the accessories and installation of a smooth sheet-

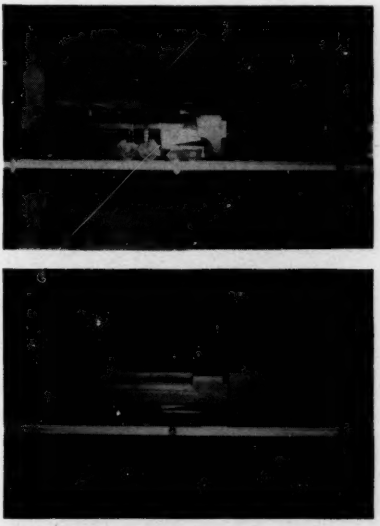

Figure 3. Streamlining a Canadian National Railway 6400 Class locomotive. At top is the original design which tended to smoke out the engineer; below is the final, smoke-free form. The tests were run in the Canadian National Research Council's John Street Tunnel, Ottawa.

metal cowling finally solved the problem; the final locomotive not only permitted good visibility, but also had 35 per cent less air drag.

Any craft designed for speed, airplane or automobile, has a natural need for the cleanest aerodynamic design, and it is never surprising to find either of these undergoing tests in a wind tunnel. Boats are inherently slow, however, and it is somewhat unexpected to find the record-breakers having their airflow "fixed up" in the wind tunnel. Several of the racing sailboats have had their sails improved by tunnel tests, and, early this summer, Sir Malcolm Campbell concluded wind tunnel tests on his remodeled "Blue Bird," the same boat with which he made the world's speed record several years ago, now redesigned and equipped with a jet engine. Tunnel tests indicated that the jet inlets will provide ample air for the engine, that the boat is aerodynamically clean, and that an excellent chance exists for establishing a new world's record.

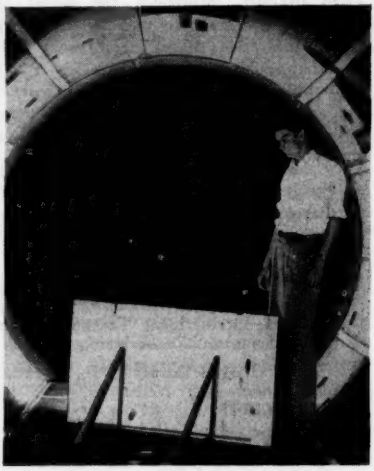

Figure 4. A sign in the Georgia Tech nine-foot wind tunnel.

OTHER FIELDS

The field of air conditioning offers much opportunity for wind tunnel tests of the duct systems, cooling towers, and outlets. In many cases, substantial savings in power can be effected by making simple elbow changes, and uncomfortable drafts from the air outlets may be eliminated by proper adjustments. A parallel case includes rainproof ventilator design; actual conditions may be simulated in the wind tunnel by an ordinary drip sprinkler with the wind furnished by the tunnel. Automobile ventilator design is tested in a similar way.

For the many industries which require air drying processes, the tunnel's wind can again be used in order to speed up the drying under controlled laboratory conditions.

Calibration of air flow instruments also is a job well done in the wind tunnel. In a few instances, companies manufacturing anemometers have set up their own tunnels for calibration purposes and for checking instruments brought in for repairs.

The signboard industry suffers from periodic losses caused by high winds and, in general, has not availed itself of the possible information the tunnel could afford. A point frequently missed in this connection is that extremely large negative pressures are quite easily attained by air as it goes around corners. Many airplanes absolutely count on averaging three times the dynamic pressure of the airstream—yet signs and many buildings are usually stressed for only the dynamic pressure itself.

Turning now to a remarkable new use of aerodynamics, we find an entire city in South America made more comfortable by a simple alteration of its natural topography: a cut made in a nearby mountain range enabled cool air to spill into the too-sheltered harbor, reducing the average summer temperature by six degrees! Breezeless cities may do well to ascertain their natural barriers, and, wherever possible, to perform those alterations that can alleviate the condition.

As can be seen, if a problem is concerned with air in motion, there is a good chance that use of controlled wind tunnel conditions can aid in its analysis and solution at a cost far below full-scale uncontrolled experiment.